# ONTOLOGY AND KNOWLEDGE REPRESENTATION

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## 1. Introduction

Ontology plays a vital part in knowledge representation. These-days e-learning packages are prepared on the basis of the ontological structure which represents the knowledge to be designed. If we talk in simple terms, we can claim that taxonomical representation of text materials in text books are nothing but a sort of ontological representations. Taxonomy is a sort of hierarchical representation of texts based on topics, sub-topics, titles, subtitles, etc. Ontology has relations which links the above mentioned items. That way ontology goes a step further form the taxonomical representations. In a way, hierarchies, typologies, taxonomies, and ontologies are related and one depend on the other or one is an extension of the other. Here we are reminded of field semantics or sematic fields propounded by Trier and expanded by Lehrer. A semantic field is a 'group of words closely related in meaning, often subsumed under a general term. The examples are kinship terms, colour terms etc. The object of analysis of semantic field is to collect all the words that belong to a field and show the relationship of each of them to one another and to the general term. The taxonomy and ontology go further to take into their folds concepts beyond words. The purpose of this paper is to elaborate on how field semantics, hierarchies, typologies, taxonomies and ontologies help us to represent knowledge there by find ways to create e-learning packages for sake of learners who wants to access knowledge in a systematic fashion.

Ontologies are a vast domain in lexical semantics and in artificial intelligence whose boundaries are somewhat fuzzy. Basically, ontology is a formal system that aims at representing for a given domain by means of basic elements, the different concepts and their related linguistic realizations. A large view of ontological knowledge can also include various forms of encyclopedic knowledge about the domain, and common-sense knowledge as well as rhetorical and metaphorical knowledge and expressions. Ontologies represent an important bridge between knowledge representation and computational lexical semantics. Ontologies are widely used as a formal device to represent the lexical content of words.

Declarative representation of knowledge has long been acknowledged as a key building block of Al systems. A knowledge base (KB) with associated reasoning mechanisms can serve as a backbone for tasks such as query answering, learning and diagnosis. One of the key challenges in deploying knowledge representation (KR) systems is the cost and the complexity of building the knowledge base, especially in cases where it needs to cover a broad domain. Building a KB is highly labor intensive for several reasons. First, the acquisition of domain

knowledge and articulating it in a formal language can be incredibly difficult. Second, since the KB needs to form a coherent logical whole, it is hard to distribute its creation of a knowledge base over multiple experts or knowledge engineers. Finally, no matter how broad the KB, it will be brittle at the edges of its knowledge - it can only be used for tasks whose knowledge needs have been anticipated in advance. While all of the aforementioned difficulties have received significant attention, together they still remain a fundamental challenge for knowledge representation technology.

Sowa (Sowa 1994, 14).presented the following informal explications of the terms 'ontology', 'terminological ontology', and 'axiomatized ontology':

"Ontology": A specification of the kinds of entities that exist or may exist in some domain or subject area. Formally, an ontology is specified by a collection of names for concept and relation types organized in a partial ordering by the type-subtype relation. Formal axioms and definition may be associated with some or all concept and relations in an ontology."

"Terminological Ontology: An ontology whose concepts and relations are not fully specified by axioms and definitions that determine the necessary and sufficient conditions of their use. The concepts may be partially specified by relations such as sub-type-supertype or part-whole, which determine the relative positions of the concepts with respect to one another, but do not completely define them."

"Axiomatized Ontology: A terminological ontology whose concepts and relations have associated axioms and definitions that are stated in logic or in some computer-oriented language that can be automatically translated to logic. There is no restriction on the complexity of the logic that may be used to state the axioms and dominions."

Sowa addressed WordNet and Cyc as large ontologies, and we can assume that he would classify WordNet as terminological and Cyc as axiomatized ontology.

Ontologies plays a crucial role in different language engineering (LE) tasks:

- Content-based tagging
- Word sense disambiguation
- Multilingual transfer, etc.

Ontological descriptions are used in a number of situations and classes of applications. Several systems tend to incorporate ontological knowledge to improve their quality and generality. Ontological knowledge can be particularly crucial for applications such as intelligent

user-front ends in natural language and automatic retrieval of documents. Ontological knowledge is used implicitly in a number of practical and theoretical approaches such as:

- Semantic networks and conceptual graphs
- Lexical conceptual Structure
- Generative lexicons
- Scenarios
- Scripts

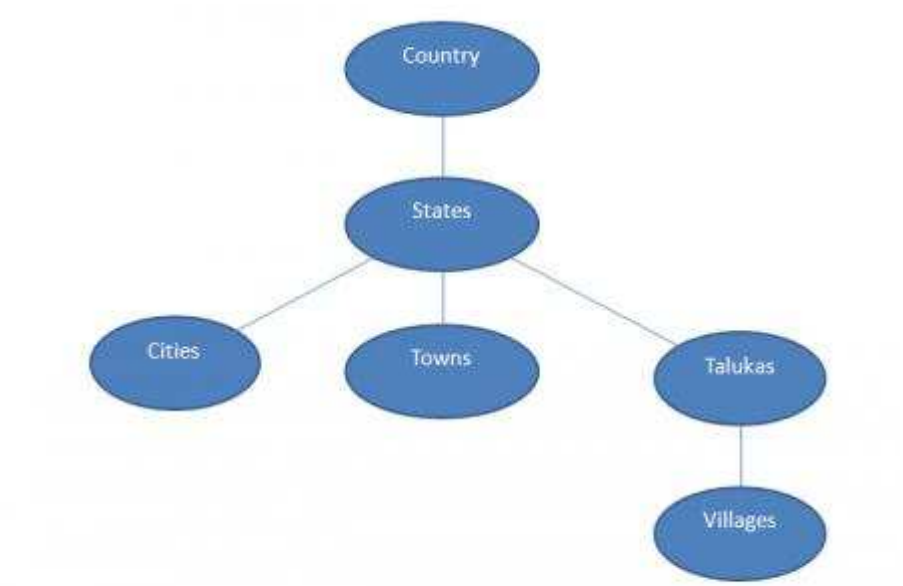
One particular task for which ontologies prove to be extremely useful is the representation of lexical knowledge, and actually this is the main reason for their renewed fortune in lexical semantics and natural language processing (NLP). Representing the meaning of a word minimally implies (i) distinguishing it by other senses the same word might have, (ii) capturing certain inferences which can be performed from it, and (iii) representing its similarity with the meaning of other words.

Building of ontologies incorporates the following structures:

- Taxonomical structure
- Lexical conceptual structure
- Qualia and inheritance structure

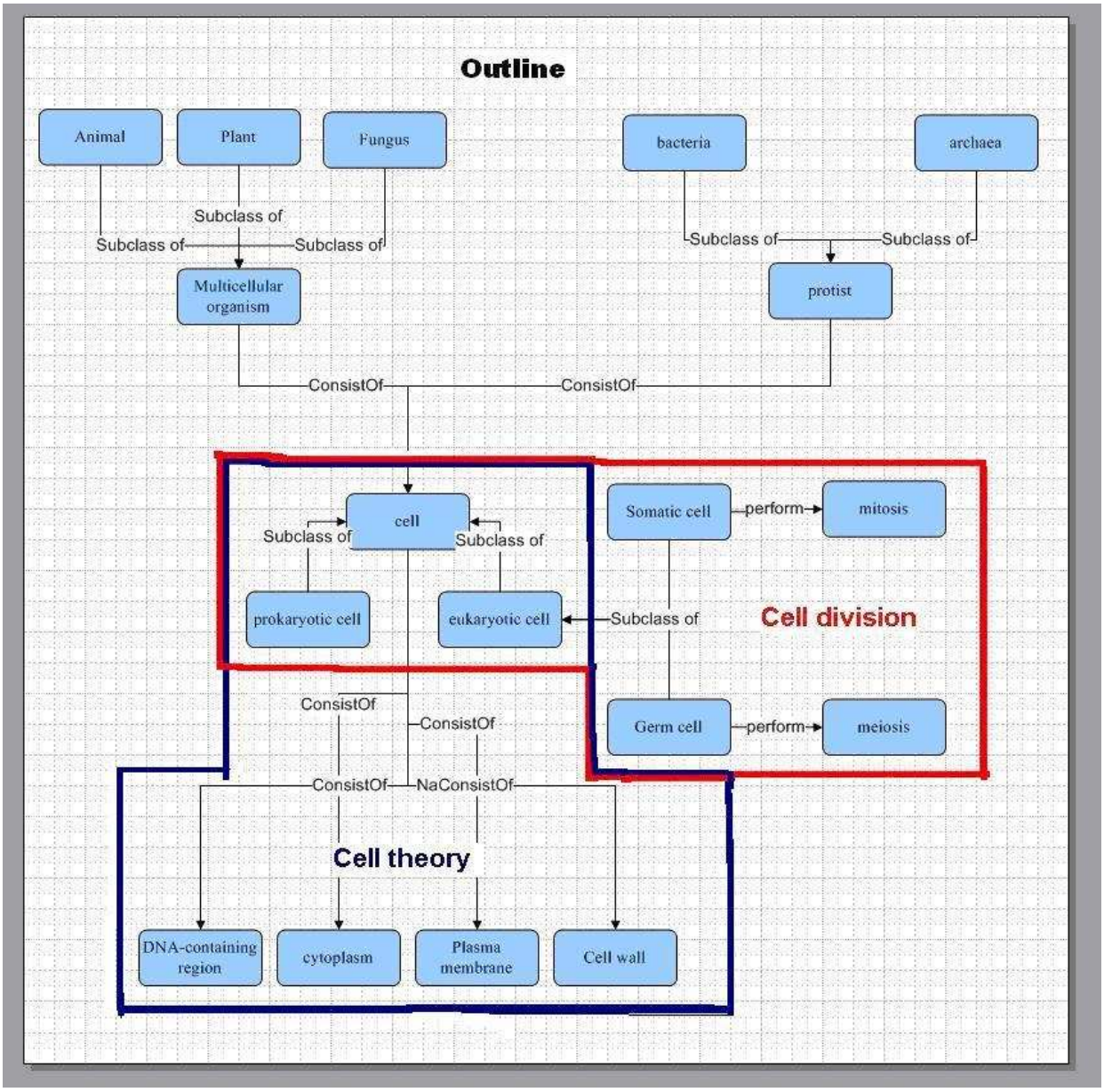
**2. Examples of ontological representations of knowledge**

The following is the ontology for the geography of a country (found from intenet).




Ontology for a geography of a country , showing hierarchy of classes

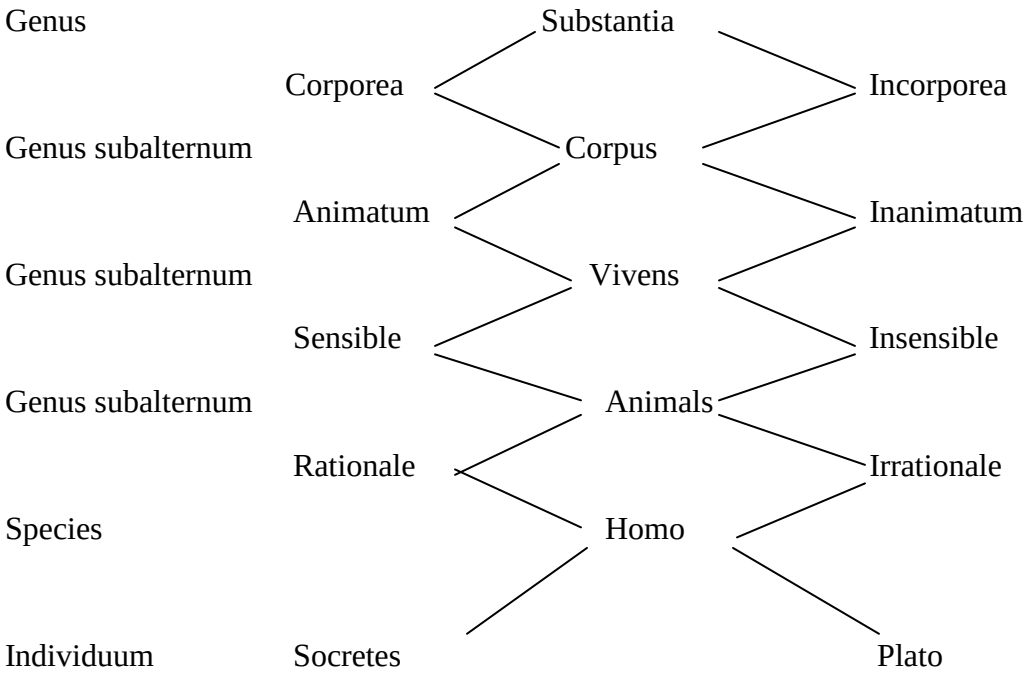
The following is the knowledge based ontology for cell (found in internet). The cell concepts are related by the relations such as ‘consists of’, ‘type of’, ‘sub-type of’ and ‘perform.




### 3. Taxonomical structure

Seventeenth century saw the raise of an attempt called universal language movement. Philosophers like Aristotle pave way to scientific taxonomy based on essences, genera, and species. This lead to the taxonomic classification of animals and plants (Salughter, 1982:29).

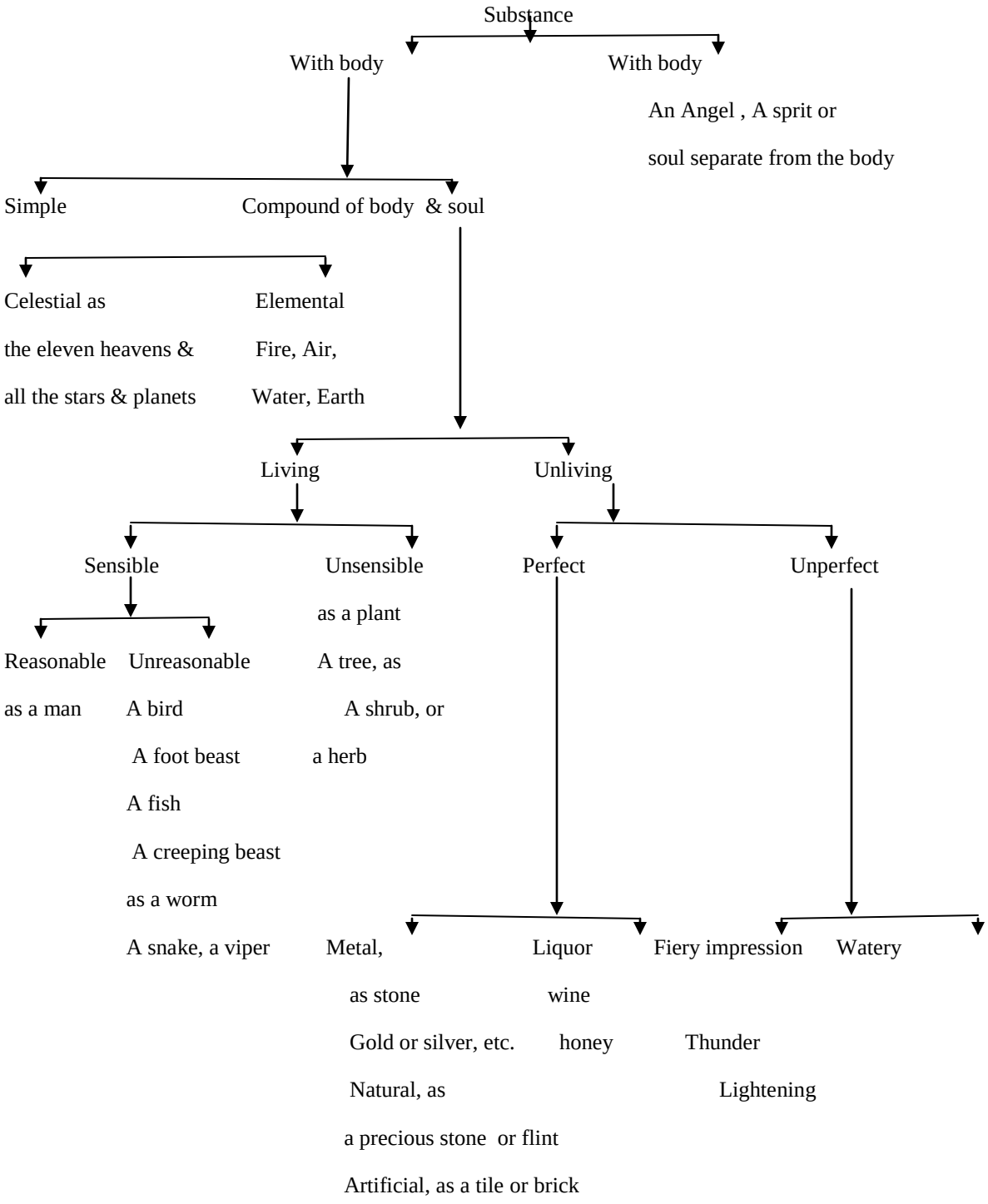
Logical Classification of the Category of Substance

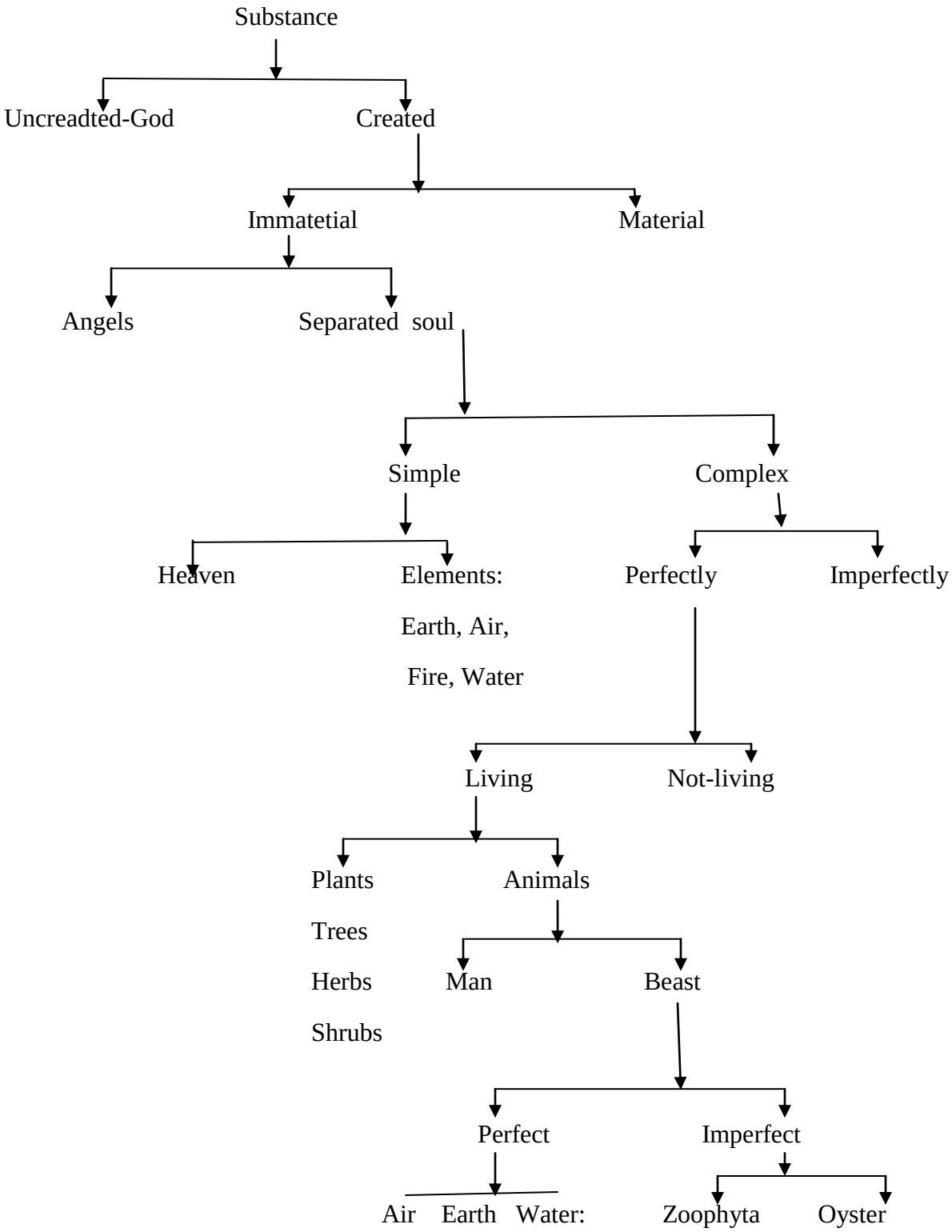



By the sixteenth to seventeenth centuries what we find in Aristotelian logic books is further division in each category and in these divisions and tables is included the philosophical and scientific lore of the age. The examples of Bludeville (Figure 1) and Du Moulin (Figure 2) are typical of the encyclopedic nature of the logic.

COMPARISON OF BERLIN'S FOLK TAXONOMY WITH A FULLY DEVELOPED HIERARCHY OF SPECIALIZED TAXA

| FOLK TAXONOMY | SCIENTIFIC TAXONOMY |
|---|---|
| Unique Beginner | Kingdom |
| Life Form | Phylum |
| Class | Order Specialized taxa |
| | Family |
| (Intermediate) | |
| Genus | Genus |
| Species | Species |
| | Sub-species |
| Variety | Variety |


Substance
With body
With body
An Angel , A sprit or
soul separate from the body
Simple
Compound of body & soul
Celestial as
the eleven heavens &
all the stars & planets
Elemental
Fire, Air,
Water, Earth
Living
Unliving
Sensible
Unsensible
Perfect
Unperfect
Reasonable
as a man
Unreasonable
A bird
A foot beast
A fish
A creeping beast
as a worm
A snake, a viper
as a plant
A tree, as
A shrub, or
a herb
Metal,
as stone
Gold or silver, etc.
Natural, as
a precious stone or flint
Artificial, as a tile or brick
Liquor
wine
honey
Fiery impression
Thunder
Lightening
Watery

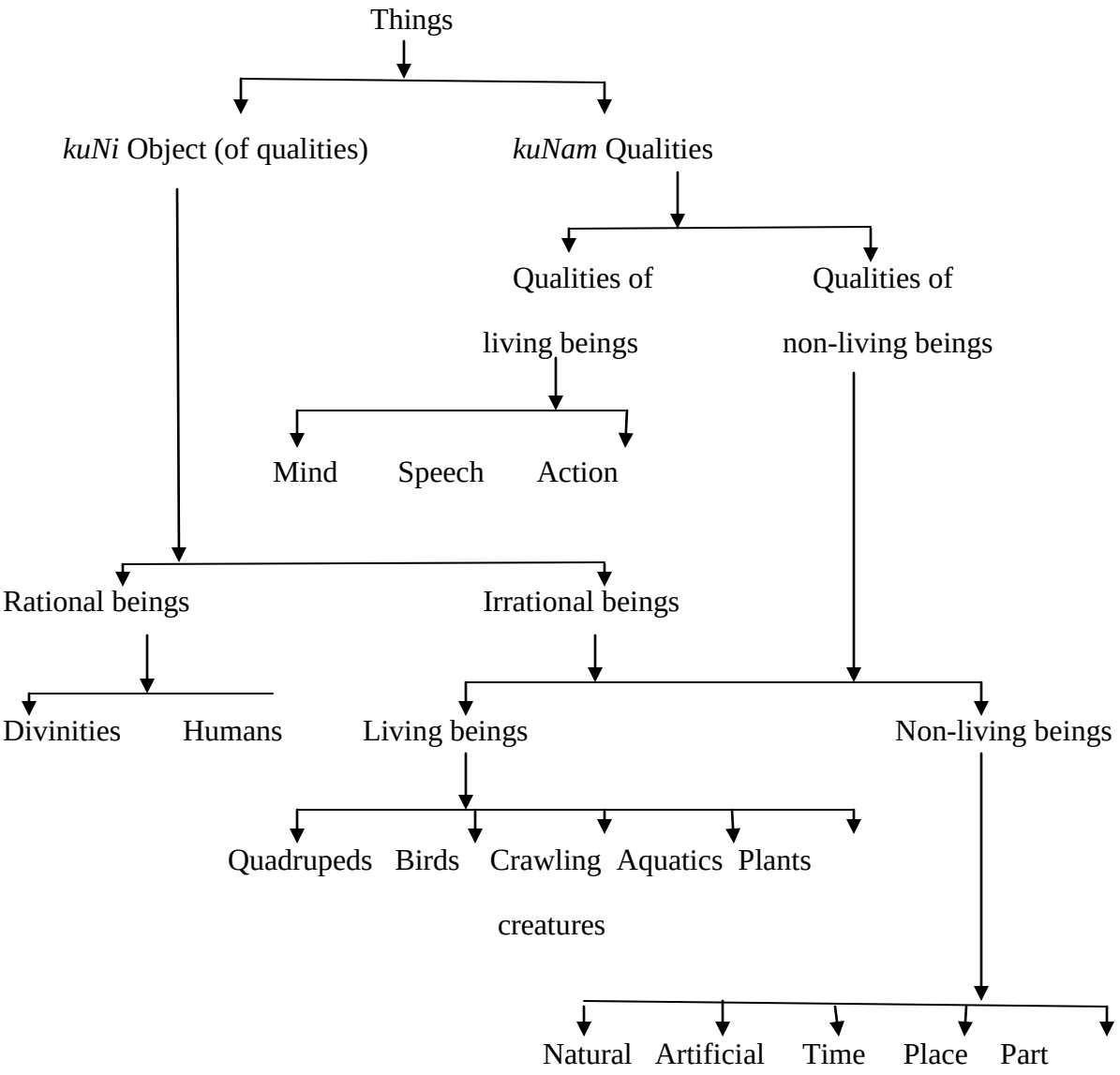

Substance
Uncreadted-God
Created
Immatetial
Material
Angels
Separated soul
Simple
Complex
Heaven
Elements:
Earth, Air,
Fire, Water
Perfectly
Imperfectly
Living
Not-living
Plants
Trees
Herbs
Shrubs
Animals
Man
Beast
Perfect
Imperfect
Air Earth Water:
Birds, Insects,
Creeping things,
Zoophyta
Oyster

From this developed the thesauruic classification of the vocabulary of a language. For example, Roget's thesaurus of English language has once such plan of classification.

ROGETS' THESAURUS: PLAN OF CLASSIFICATION

| Class | Section | Sub section |
|---|---|---|
| ABSTRACT RELATIONS | I. Existence | |
| | II. Relation | |
| | III. Quantity | |
| | IV. Order | |
| | V. Number | |
| | VI. Time | |
| | VII. Change | |
| | VIII. Causation | |
| SPACE | I. In General | |
| | II. Dimension | |
| | III. Form | |
| | IV. Motion | |
| MATTER | I. In General | |
| | II. Inorganic | 1. Solids |
| | | 2. Fluids |
| | III. Organic | 1. Vitality |
| | | 2. Sensation |
| INTELLECT | I. Formation of Ideas | |
| | II. Communication of ideas | |
| VOLITION | I. Individual | |
| | II. Intersocial | 1. In General |
| | | 2. Possessive relations |
| AFFECTIONS | I. In General | |
| | II. Personal | |
| | III. Sympathetic | |
| | IV. Moral | |
| | V. Religious | |

*Nikhantu* of Sanskrit tradition gives an ontology in which things are classified into objects and qualities. Qualities are again classified into qualities of living beings and qualities of nonliving beings.




Development of lexical semantics leads to taxonomic classifications vocabulary and concepts which carry them.

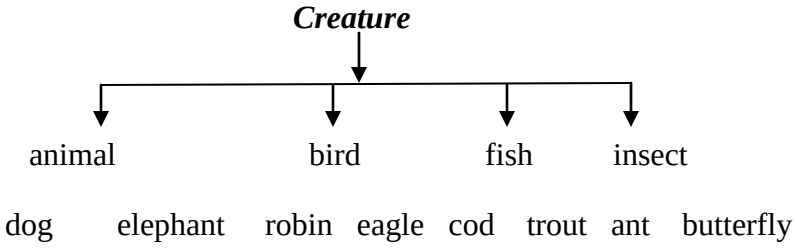
**4. Hyponymy and Taxonomy**

Hyponymy and its consequence taxonomy are the fundamental building blocks of ontology. Hyponymy and its natural partner, incompatibility, are described by Lyons as "the most fundamental paradigmatic relations of sense it terms of which the vocabulary is structured".

Lyons states that taxonomic lexical hierarchies are structured by the relations of hyponymy and incompatibility.

## 5. TAXONOMIES

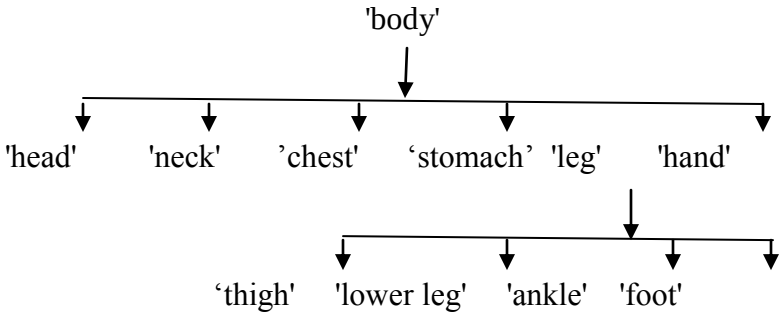
### 5.1. Hyponymy and incompatibility




There is no inherent connection between hyponymy and incompatibility**.**

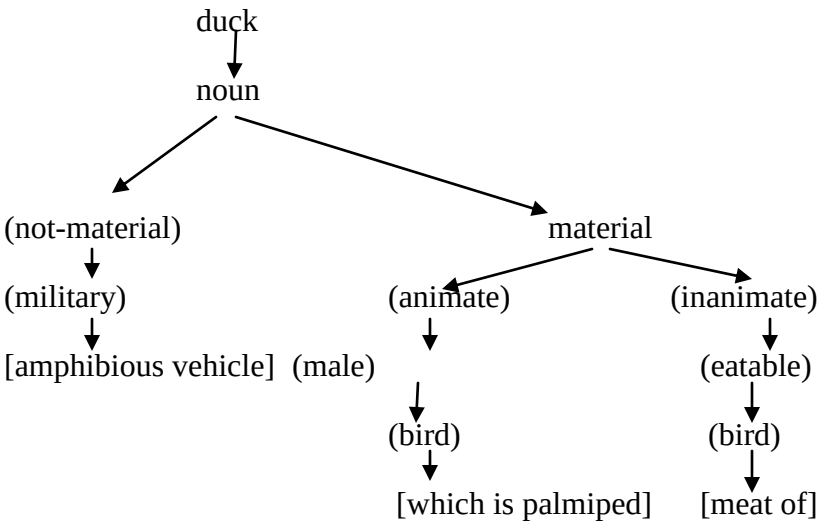
### 5.2. Meronymic relationships

Meronymic or patronymic relations are ontological relations that are considered as fundamental as the ubiquitous, taxonomic subsumtions relationship.




In componential analysis, the sense of a word is defined as a set of features that distinguishes it from other words in the language. The meaning of a lexical item is analyzed in terms of atoms of senses (the terminal elements of the tree-structure). For example, the word 'duck' is defined by the following notions: syntactic marker, (semantic markers), [semantic differentiations], <syntactic or semantic contextual delimitation>:

COMPONENTIAL ANALYSIS MODEL




Componential analysis gives scope for multiple ways of analyzing concepts. The following gives the prototypical attributes to the concepts 'tower' and 'piano' which are crucial in the understanding of these terms in discourse.

**Prototypical attributes to tower and piano**

| Tower | Piano |
|---|---|
| Height | Acoustics |
| Age | Shape |
| Beauty | Colour |
| Strength | Beauty |
| Price | Price |
| Profitability | Material |
| …. | …. |
| Weight | Weight |
| …. | …. |
| Chemical composition | …. |

Nida offers a typological classification of concepts of the vocabulary of a language. He did it for the sake of bible translation across languages.

**6. Nida's Hierarchical Classification based on componential analysis of meaning**

Nida (1975) who was concerned with the preparation of a thesaurus dictionary for Greek gives the following as the tentative hierarchical classification of the lexical items (Nida, 1975:178-186).

I. Entities

A. Inanimate

1. Natural

a. Geographical

b. Natural substances

c. Flora and plant products

2. Manufactured or constructed entities

a. Artifacts (non constructions)

b. Processed substances: foods, medicines, and perfumes

c. Constructions

B. Animate entities

1. Animals, birds, insects

2. Human beings

3. Supernatural power or beings

II. Events

A. Physical, B. Physiological, C. Sensory, D. Emotive, E. Intellection, G. Communication, G. Association, H. Control, I. Movement, J. Impact, K. Transfer, L. Complex activities, involving a series of movements or actions

III. Abstracts

A. Time, B. Distance, C. Volume, D. Velocity, E. Temperature, F. Color, G. Number, H. Status, I. Religious character, J. Attractiveness, K. Age, L. Truth-falsehood, M. Good-bad, N. Capacity, O. State of health, etc.

IV. Relationals

A. Spatial, B. Temporal, C. Deictic , D. Logical, etc.

**7. Lexical conceptual structures**

**Conceptual graphs**

Concepts are language independent ones derived from percepts. A conceptual graph is a finite, connected, bipartite graph. The two kinds of nodes of the bipartite graph are concepts and conceptual relations. Every conceptual relation has one or more arcs, each of which must be linked to some concept (Sowa, 1984).

[CAT] → (ISA) → [ANIMAL]

[PENCIL] → (ISA) → [INSTRUMENT]

↓

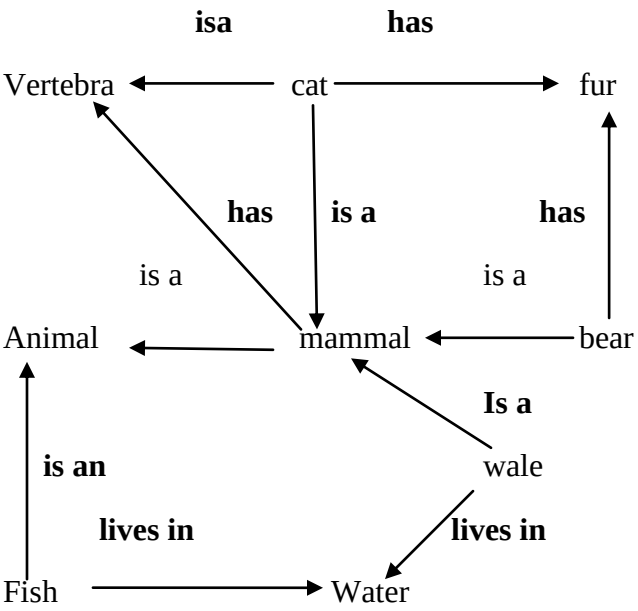
(FUNCT)

↓

[WRITING]

**8. Semantic Network**

A semantic network is a network which represents semantic relations among concepts. This is often used as a form of knowledge representation. It is a directed or consisting of vertices, which represent concept and edges (Sowa, 2009).




Concepts, abstractions, aggregation, individuation, definitions, descriptions, types, prototypes and models can be represented in semantic network. Semantic network can be used for building knowledge representation too.

**9. Qualia and inheritance structure**

Pustejovsky (2001:56) characterize a generative lexicon as a computational system involving at least the following levels of representation

1. ARGUMENT STRUCTURE: Specification of number and type of logical arguments
2. EVENT STRUCTURE: Definition of the event type of an expression and its subeventual structure
3. QUALIA STRUCTURE: A structural differentiation of the predicative force for a lexical item
4. LEXICAL INHERITANCE STRUCTURE: Identification of how a lexical structure is related to other structures in this type of lattice

Pustejovksy assumes that the word meaning is structured on the basis of four generative factors, or qualia roles:

CONSTITUTIVE: the relation between the object and its constituent parts

FORMAL: the basic category that distinguishes the object within a larger domain

TELIC: the object's purpose and function

AGENTIVE: factors involved in the object's origin or "coming into being".

Ex.

book (*x*)

[Formal: book-shape (*x*)]

[Constitutive: {page, cover,…}]

[Telic: read (T,y,*x*)]

[Agentive:artifact (*x*), write(T,z,*x*)]

dictionary (*x*)

[Formal: book (*x*),disk (*x*)]

[Constitutive: alphabetized-list (*x*)]

[Telic: reference (P,y,*x*), consult (T,y*x*)]

[Agentive: artifact (*x*), compile (T,z,*x*)]

Generative lexicon theory handles the polysemy of words by making use of the generative mechanisms such as type coercion, selective binding, and co-composition. These mechanisms tackles the lexical ambiguity as reflected in the following examples.

We will need a fast boat to get back in time.

John is a fast typist.

Fast drivers will be caught and ticketed.

John wants a beer (to drink)

Mary wants a book (to read)

Harry wants another cigarette (to smoke)

Mary baked the potato.

Mary baked the cake.

## 10. CONCLUSION

The area of ontology has expanded so much that it is possible to represent all kinds of knowledge, whether it is linguistic or non-linguistic, by ontologies. Many hierarchies, typologies and taxonomies are converted to ontologies so as represent the knowledge incorporated in them. Ontological representation comes handy for the preparation of e-learning packages.

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